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ABSTRACT

The problem of this conference panel was to determine the interaction between the structural properties of text and the cognitive processes involved in comprehension. This panel report contains sections on the organization of the message in the communication system, the information readers derive from a message and how well they derive it, the process of going from sound (or print) to meaning, knowledge growth and use, and bilingualism. The last section consists of models of the process of extracting meaning from discourse, including models of language understanding and computer models of language acquisition. Lists of priorities and recommendations and of references are included. (JM)

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the structure and use of language

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CONFERENCE ON STUDIES IN READING

"It was unlawful, as well as unsafe, to teach a slave to read.

'It will forever unfit him to be a slave. He will at once become unmanageable and of no value to his master.'

These words sank deep into my heart. From that moment, I understood the pathway from slavery to freedom. Though conscious of the difficulty of learning without a teacher, I set out with high hope and fixed purpose, at whatever cost of trouble, to learn how to read."

Frederick Douglass

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July, 1975

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PANEL 2

THE STRUCTURE AND USE OF LANGUAGE

PROBLEM STATEMENT

Determine the interaction between the structural properties of text and the cognitive processes involved in comprehension.

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PANEL 2

THE STRUCTURE AND USE OF LANGUAGE

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PREFACE

The National Institute of Education (NIE) came into being during 1972. Its authorizing legislation requires the NIE to:

- Help solve or alleviate the problems of, and achieve the objectives of, American Education.
- Advance the practice of education as an art, science, and profession.
- Strengthen the scientific and technological foundations of education.
- Build an effective education research and development system.

In order to aid in meeting these general objectives, the National Council on Education Research (NIE's policymaking body) approved the creation of five priority programs in December, 1973. One of the priority programs was Essential Skills.* Its purpose was:

> To investigate through research and development, ways to aid all children to obtain skills essential for functioning adequately in school and society.

The initial focus of the Essential Skills Program was in the area of reading. Broad guidelines for an NIE effort in reading had been developed in a small conference held on Cape Cod during the late summer of 1973.** During 1974, the Essential Skills Program carried out an intensive effort designed to formulate more specific plans for funding research and development activities in reading. A variety of meetings were held with groups of teachers, school administrators, and scientists to designate directions for the program. The most ambitious of the meetings was held in Washington, D.C., in August, 1974, and directly involved over 175 individuals -- 50 as Conference participants and 125 as consultants to the Conference. This report is the product of one of the 10 panels of the August Conference.

The impetus for the Conference stemmed from a number of concerns about the state of Federal funding of research and development in education. Four concerns stood out in particular for reading.

1. Research in the field of reading was fragmented and noncumulative.

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*During the past few months, the Essential Skills Program has been renamed the Learning Division of the Basic Skills Group. Both the Basic Skills Group and the Learning Division continue to follow the guidelines set out by the National Council in December, 1973 (above).

**See Miller, George A. (ed.) Linguistic Communication: Perspective for Research, International Reading Association; Newark, Delaware, 1974, 45 pp.

2. The Federal Government was not making constructive use of the state of knowledge in the field in their decisions to fund new research and development.

3. There was a lack of positive and firm coordination between the Federal Government and the professional research and practitioner organizations around the country.

4. A large number of scientists in a variety of disciplines carry out research with relevance to reading. We considered it important to attract these scientists to work in the applied areas of educational research.

The Conference itself was a step in meeting these concerns. During the past year, the NIE has been developing plans for funding research and development in reading for the next two years. Suggestions from the Conference have played an important role in this process. But planning is an ongoing process and we hope by publishing and widely disseminating the reports from the Conference to stimulate discussion of the reports, of research and development in the field of reading, and, indirectly, of the plans of the Institute.

To some extent the format for the Conference was influenced by three other similar efforts of the Federal Government. In the area of health research, the conferences leading to the National Cancer Plan and the National Heart and Lung Institute Plan served as partial models. Within NIE, the Teaching Division had held a major planning effort in the area of teaching research during the early summer of 1974. The intent in each of these efforts was to develop a coherent set of documents that would be responsive to the needs of the American public and to knowledge in the field.

We felt it necessary to structure the Conference in two important ways. First, after extensive consultation with scientists and practitioners in the field we arrived at the conclusion that major efforts in the past had often ignored or down-played the critical importance of the stage of reading called "reading comprehension." Although we realized the impossibility of actually separating out "reading comprehension" from the earlier stage of learning to read -- which requires the learner to be able to translate written letters and words into speech -- our advice suggested that the comprehension or "reading for meaning" stage required far more attention than it had received in the past. Consequently, seven of the ten panels focused on problems in this area. Second, to direct the focus of the panels to planning future research we requested the panelists to organize their ideas into general approaches within the problem area, within the approaches to suggest programs for research, and, finally, when possible to specify particular research or development projects.

The seven panels addressing problems in comprehension spanned a wide range of concerns. The first three panels focused on basic research issues. Their panel reports are titled: Semantics, Concepts, and Culture; The Structure and Use of Language; and Attention and Motivation. The fourth panel was asked to consider the problem of Modeling the Reading Process. The fifth panel directed its attention to the issue of measuring how well people read and its report is titled Assessment of Reading Comprehension. The sixth and seventh reports directed themselves respectively at the practical problems of the Application of Existing Reading Comprehension Research and Reading Comprehension and the High School Graduate. The final three panels directed their attention to three pressing concerns in early reading: Learning and Motivation in Early Reading; Reading Strategies for Different Cultural and Linguistic Groups; and Essential Skills and Skill Hierarchies in Reading.

Although the reports have undergone some revision and editing since the Conference, the major part of the work was done in concentrated sessions in the space of a few days. The resulting documents are not polished or exhaustive. They are meant to be working documents to stimulate debate, suggestions, and comments. Such comments or requests for other reports should be directed to:

Director, Learning Division
National Institute of Education
Washington, D.C. 20208

The work of organizing the Conference was carried out by members of the Essential Skills staff at the NIE -- each of the panels had an NIE staff person as a permanent liaison. Special acknowledgments are due to Susan Duffy and Donald Fisher for their assistance in preparing the reports for publication and to Arthur Young & Company for coordination and arrangements before, during, and after the Conference. Finally, the work of NIE cannot proceed without the kind of skill, involvement, and hard work given by the panel chairpeople, panelists, and consultants for this Conference. The ideas and emphases in the reports are the products of their cumulative expertise.

Marshall S. Smith
Conference Chairperson

LIST OF PANEL REPORTS AND CHAIRPERSONS

1. Semantics, Concepts, and Culture, Dr. George Miller, Rockefeller University

2. The Strutture and Use of Language, Dr. Thomas Trabasso, Princeton University

3. Attention and Motivation, Dr. Sheldon White, Harvard University

4. Modeling the Reading Process, Dr. Richard Venezky, Wisconsin University

5. Assessment of Reading Comprehension, Dr. Ernst Rothkopf, Bell Laboratories

6. Application of Existing Reading Comprehension Research, Dr. Lauren Resnick, University of Pittsburgh

7. Reading Comprehension and the High School Graduate, Dr. Mina Shaugnessy, City University of New York

8. Learning and Motivation in Early Reading, Dr. Richard Hodges, University of Chicago

9. Reading Strategies for Different Cultural and Linguistic Groups, Dr. Manuel Ramirez, University of California, Santa Cruz

10. Essential Skills and Skill Hierarchies in Reading, Dr. Irene Athey, University of Rochester

PANEL 2

THE STRUCTURE AND USE OF LANGUAGE

INTRODUCTION

A person acquires knowledge from others in at least three main ways: by seeing what they do, by hearing what they say, and by reading what they write. The first method involves a "nonlinguistic" context. The second two ways involve language comprehension and share common elements and psychological processes. We can view all three as organized sources of information. Communicators may purposefully structure information to convey their intentions. Recipients have to use both the context and the message to decide what the sender means. To do so, they draw upon their own knowledge and skills (perceptual, linguistic, and cognitive) to interpret the communication. The study and analysis of the structure of the message and the processes of comprehending it are basic research problems. Their investigation should lead to a greater understanding of the total system by which one acquires knowledge. It should also lead to improved methods of constructing written materials, better training procedures for conveying and understanding communicated information, increased appreciation of differences among people in terms of what they know and what they are capable of doing, and better communication with children. In short, at every practical level, greater understanding of language structures and processes should result in improved technologies for teaching children to read.

PROBLEM AREA DESCRIPTION

Problem Area Statement

The purpose of the panel was to analyze the structural properties of discourse or text, the basis for generating a discourse, and the interaction of the properties of the discourse with the processing characteristics of the reader. In addition, we recognize that the nonlinguistic context is a critical factor in determining what knowledge recipients acquire when they "understand" the discourse.

In order to provide a setting in which to analyze reading comprehension, we shall view the teaching situation as a communication system. (Spoken language comprehension may be analyzed in a similar fashion.) Written communication involves the transmission of information from one person to another. The information consists of intentions, goals, concepts, experiences, and possible logical inferences. It is transmitted via strings of words connected in the form of written text; often these strings are in the context of other events, but, at times, they have no supporting context.

A system of written linguistic communication can be characterized by five steps:

1. A writer takes from personal knowledge an organized set of information for transmission.

2. The writer develops the information into a message--a group of words that is "well-formed" and natural. In most situations, a message does not involve single words or single sentences. Written material is usually complicated, and must be stated in several related sentences called a connected discourse.

3. The reader physically receives the message by reading printed material.

4. The reader understands, i.e., goes from the printed words to meaning. The reader tries to interpret the intentions, concepts, etc., of the writer. In essence, the word strings are transformed at physical reception. The message is transformed into semantic or conceptual information by the reader.

5. Finally, further mental operations upon the interpreted information organize and store it in the reader's memory so that it is available for further use or action. The organization and the content of the information placed in memory is called a representation of the message.

This panel will focus on the organizational properties of what the writers and readers know; on the organizational properties of the message; on the means or processes by which the writers create the message; on the processes by which the readers comprehend the meaning of the message; on the structural properties of what information readers derive from the message and store in memory; and on the context in which the message occurs, including its social function or physical referents.

A structural description of a message includes semantic, syntactic, and logical components. Understanding the correspondence between the information intended to be transmitted by the writer and the information received by the reader requires an analysis of prior experiences of both people, the extent to which they have shared knowledge, how their knowledge is organized in their memories, and how they interpret or perceive the present context in the light of their knowledge of the world. The production and understanding of the message entail a variety of psychological processes which we can understand as a sequence of mental operations or transformations upon information which, in turn, results in new, organized knowledge.

We focus, then, on the structural and processing aspects of language transmission and understanding. We believe that there are processes and structures common to both listening and reading. Thus, research on one activity should be directly relevant to our understanding or appreciation of the other activity.

We recommend support of research that analyzes or involves either spoken and heard or written and read texts, and encouragement of research on each of the five stages in the communication process. Because structural characteristics are of interest, we believe that research on connected discourse involving more than single sentences should be encouraged. Highly organized and complex sequences of processes are involved in the generation and understanding of messages, so we recommend support for the development of theory or models that describe these processes. We recognize that language comprehension is highly dependent on context and recommend support of research which takes this into account in a systematic, process-oriented way. We believe that the study of persons who must, of necessity, learn two languages is valuable for basic research and for social reasons.

Although the research we recommend is admittedly ambitious, it is realizable. Through the recent efforts of linguists, philosophers, sociolinguists, logicians, computer scientists, and psychologists, a body of knowledge, skills, and methods has arisen which can shed light on each or several of the stages. The interdisciplinary character of the research attests to the complexity of the problem. It also testifies to the current interest in generating new knowledge and understanding by a variety of people of different backgrounds. We hope to take advantage of this ferment of activity.

Problem Area Potential

While much of what we recommend is research-oriented we must recognize the potential application of each of these approaches to education and communication. If we know the basic goals, intentions, and concepts to be communicated, and if we have procedures for using them to generate speech or written discourse, it may be possible to use these procedures to generate coherent, structured texts that are readily understood, interesting and are accurate and efficient in communicating the information. We would then know the content and structure of our written materials. If we understood the details of the processes by which individuals understand material, we could locate problems or failures to comprehend, and design training procedures to build skills that lead to more efficient processing. Knowledge of the context in which a message occurs may also aid in its transmission, reception, and comprehension. Differences in cultural experience may aid or hinder communication, and we may find methods to create a shared knowledge base or transfer of language skills from one social situation to another.

More specifically, there are several contributions basic research can make to instruction in reading comprehension. First, we note that the measurement of what individuals comprehend is critical if we are to assess the effect of such instruction. The ability to analyze systematically the content in a text will facilitate measurement of that content. For example, a text may state explicitly that the girl is to the right of a tree and the tree is to the right of the boy. One possible inference from the text, however, is that the boy is to the left of the girl. Readers who can make such an inference seem to have an understanding of the various relationships among people and objects described in the text. One way to test comprehension of texts might be to test readers' abilities to make those inferences which can be drawn from the information present in the text. A systematic, structural analysis of text would facilitate this method of testing by providing a clear indication of what information was explicit in a text and what readers could infer. The present focus on recall of content words alone as a measure of reading comprehension is limited to vocabulary per se and does not test the understanding of semantic relationships among words within and across sentences. Thus, one potential contribution of this research will be schemes for analyzing and scoring prose passages so that we can make a more accurate assessment of comprehension.

Another related example has to do with possible strategies for comprehension involving the analysis of relationships among words in text. That is, it may be possible to teach young readers methods of analyzing what they are reading for deeper meaning than usual. In effect, one would be teaching children how to question the passage, thereby prolonging their attention to the text and deepening the level to which they actually read or process it.

Finally, knowledge of the rules for generating written text from a set of basic ideas and the relative ease with which various constructions are understood could lead to a technology for writing children's readers to meet criteria of readability, interest, and appropriateness to age and experience. Current practices are left largely to individual writers and commercial houses with few guides other than basic vocabulary counts and their own intuition.

Division of the Problem Area

Approach 2.1 focuses on the organization of the message in the communication system. It asks: How is the text organized? What information does the text contain explicitly? and, What information must readers infer? Because the text is the immediate source of information, knowledge of the characteristics of text should improve our understanding of which information is explicit and which is to be inferred. Analyses of these characteristics could suggest the basic units and organizational rules for generating a text and help us organize texts for more effective communication (Programs 2.1.1, 2.1.2).

Approach 2.2 focuses both on what information readers derive from a message and on how well they derive it. By looking at what they can paraphrase, recall, recognize, infer, answer, describe, retell, etc., we hope to be able to discover the relationship between the information in a text and the information gleaned from the text by the reader. We also ask: How well did the readers infer the intentions of the writers? What knowledge did they use to do so? How was their knowledge altered or what new information did they learn? (See Program 2.2.1.) We discuss methods for measurement (Program 2.2.2), and suggest means for development of tests of comprehension (Program 2.2.3). We take into account individual differences among readers (Program 2.2.4) and describe how language is developed or acquired (Program 2.2.5). Finally, in Program 2.2.6 we ask whether listening involves the same processes as reading, a common but unsubstantiated assumption.

Approach 2.3 focuses on the process of going from sound (or print) to meaning. By knowing the semantic structure of the text and the semantic structure of what a person has derived from it, we hope to develop theories about how one goes from one semantic structure to the other. This approach is intimately tied to Approach 2.6 which suggests the use of computer models to describe in detail comprehension processes. These models should, in theory, be able to capture the full system. From a set of basic propositions, one could generate a text, and decompose it back into its meanings. However, we need linguistic and logical analyses of the text to facilitate the development of the propositional base upon which the processes of generation operate and toward which the processes of decoding move. In Approach 2.3 we examine variations in text content and structures with respect to their effects on the understanding of a message by the readers (Programs 2.3.1, 2.3.2, and 2.3.3).

Approach 2.4 deals with a problem that everyone knows exists, but few are willing to acknowledge. Language comprehension does not occur in a vacuum. All sorts of nonlinguistic factors affect communication. These factors are "nonverbal" and center on pragmatics and other behaviors of speakers (gestures, intonation, stress, tone, etc.). Pragmatics is a branch of linguistics concerned with how people actually use language, that is, how they use language in social situations where expectations and prior experience, social conventions, etc., play a role. This approach suggests that language is context-bound, especially for children. The approach questions whether the emphasis on formal structures, depth of linguistic processing, etc., which characterize Approaches 2.1 through 2.3 and 2.6 is really important. The implications are considerable. At the same time, Approach 2.4 does not lend itself to detailed analyses (as do texts or postulated mental processes of comprehension) and this lack of detail may be its shortcoming, despite its obvious importance.

In Approach 2.4, we suggest that context become a focus of study. We urge examination of language and reading comprehension in a rich, supporting context versus the educational context of reading which is less dependent upon such support (Program 2.4.1). Development of reading skills is assumed to move from dependence upon concrete situations and informal language use toward less context-rich environments and more formal, abstract language. Developing readers become less dependent on external factors, pictures, things, etc., and more dependent on their own internalized knowledge structures and formal language skills (studied in Approaches 2.1 through 2.3 and 2.6). We call this process of growth "decontextualization" (Program 2.4.2). It may become a central concept for language development.

In our analysis, we seem to be preoccupied with structure, organization, process, context, etc. We define comprehension as extracting meaning in terms of propositions. Program 2.4.3 questions this particular definition and asks: How do we know that we have understood something? How can we self-evaluate our comprehension? We can further ask: What implications does this approach have for early reading instruction? Can we develop ways to help children orient themselves toward reading so that they perceive the intended meaning more readily and can use their own actions to aid in the learning process?

In Approach 2.5 we focus on bilingualism. We recognize a need for a clear identification of those who are bilingual (Program 2.5.1). Some people understand two natural languages, but speak only one. Some understand and speak both. The developmental sequence of learning the language varies. We might ask whether these experiences and skills lead to different semantic structures, and whether these structures are independent, coordinated, or confounded. We would like to know the extent to which language is separate from cultural context. Program 2.5.2 explores these issues.

We have alluded to the use of computer artificial intelligence devices to generate text and to simulate complex comprehension processes. Ultimately, the whole communication system could be explored in a simulation. However, in Approach 2.6 we focus primarily on parts of the system in an effort to create explicit, testable computer models which are psychologically relevant and which would help us to study component processes not easily investigated by other means. Two programs are described. In Program 2.6.1, the focus is on language comprehension, i.e., how the person goes from text to meaning. We describe current research efforts and suggest projects relating to them. Program 2.6.2 is a new and important, but difficult, adventure: the devising of a machine that can learn a language. There is no definitive theory of language acquisition; we hope to encourage its development through the use of one of the most powerful theoretical tools available--the computer.

APPROACH 2.1

STRUCTURAL ANALYSIS OF TEXT

Approach Statement

Explore and extend linguistic, psychological, and computational approaches to discourse (text) analysis and production.

Approach Potential

Until relatively recently, linguists influenced by Chomsky have tended to restrict their attention to the sentence as the largest unit of analysis. They have emphasized syntax at the expense of meaning or semantics in representing sentence structure. Criticisms of these two aspects of Chomsky's theory, the emphasis on syntax and the adoption of the sentence as the unit of analysis, have motivated much recent work in linguistics and have led to a new emphasis on semantics and on discourse as the unit of analysis.

With respect to the first criticism, generative semanticists have begun to believe that there is no formal difference between so-called syntactic and semantic rules. Projection rules which map deep structure onto a semantic representation and transformations which map deep structure into well-formed surface structures have been given up in favor of a single system of mappings.

With respect to the second criticism, many researchers have criticized taking the sentence as the primary unit of analysis and defining the grammaticality of a sentence without reference to the context in which the sentence occurs. They have pointed out that certain derivations of a sentence may be judged ill-formed in one context, yet grammatical in another. Thus, speakers apparently have an ability to make judgments of grammaticality reflecting the context in which a sentence occurs. Here, context means the words surrounding another word within a sentence, or the sentences preceding and following another sentence. The basic idea is that the sentences are related or "connected" in meaning. Hence, we use the term "connected discourse" to convey the idea that words and sentences are all interrelated in a message. Any linguistic theory attempting to define grammaticality in isolation from context will be an inadequate model of speakers' competence. This realization has led many linguists to give increased attention to the effects of context.

In this work, we have given attention to (a) the conceptual context of an utterance, the presuppositions (beliefs or intentions) held by a speaker at the time of an utterance; (b) the extralinguistic context,

the time, place, and location of speakers and the identity of speaker and hearer; and (c) the linguistic context, the context given by previous discourse within which a sentence is embedded. The importance of these contextualization factors as well as the claim that speakers' competence (ability to judge grammaticality) pertains specifically to texts (and to sentences as special cases of texts) has led some linguists to propose considering the text as the unit of analysis (Sanders, 1970) and to attempt to develop text grammars (Van Dijk, 1973; Gulstad, 1973). An adequate text grammar would not only have to be capable of generating semantically and syntactically well-formed sentences within a discourse. It would also have to generate sentences which "fit" the context of the relevant discourse.

In the face of recent developments in our understanding, it would now appear possible to develop text grammars, at least for some limited class or classes of text types (such as children's reading materials). The development of text grammars not restricted to relatively limited classes of discourse will probably not occur in the near future. (See also Approach 2.6.)

Approach Rationale

A necessary prerequisite to research on the structural properties of text and their interaction with the processing characteristics of the reader is the development of a linguistic model of discourse structure. Such a model is necessary (a) for use in characterizing the structural characteristics of text materials presented to experimental subjects, (b) as a basis for systematic study of the effects of structural characteristics of text (logical, semantic, and grammatical) on discourse comprehension, and (c) as a basis for assessing semantic information which people acquire when they understand text. Approach 2.1 focuses on linguistic or computational linguistic projects, having as an immediate goal the development of linguistic models of discourse with the following characteristics: (a) the models are semantically based, and (b) rules of grammar are stated relative to context, including discourse context, extralinguistic context, and conceptual context. It is very important that this work attempt to develop a model at the discourse level which may be readily applied in research on effects of discourse structure on comprehension processes.

Division of the Approach

There are two possible ways of attacking problems of discourse structure. The first would involve attempting to use existing linguistics to write computer programs capable of generating some restricted class of English (or Spanish) texts or of analyzing a restricted class of texts. Program 2.1.1 makes suggestions here. The second would involve further linguistic work on contextual factors and their incorporation into discourse grammars.

Programs 2.1.2 and 2.1.3 are variations on the latter analysis. All three programs are viewed as being interrelated, but could occur parallel with one another. It is clear, however, that an advance in one program would influence progress in another because they share common problems.

Program 2.1.1: Computer Models of Text Structure.

Program Statement

1. Develop a computer program capable of generating grammatical English (or other languages important to Americans, such as Spanish) texts from a propositional base, given as input to the program the base structure and other information such as topic, context, location and time reference of the speaker, order of events, etc.

2. Develop a computer program capable of generating a semantic structure for a text given English (Spanish) texts as input. The program should deal with the problems of ambiguity and reference in the text. The semantic structure should include both semantic relations expressed within sentences or clauses, and logical relations which connect propositions and are expressed across sentences or clauses. (See Approach 2.6 for further discussion of computer models.)

Program Potential

Computer programs provide convenient ways to state linguistic models. Semantic networks have already been represented as data structures in computer programs (i.e., Simmons, 1973, and Schank, 1973). It appears that it should be possible to build (from existing programs and work on discourse in linguistics and psychology) text grammars capable of generating or analyzing some limited classes of textual materials such as children's stories or folktales.

Program Research Considerations

There are two ways of using a model of text structure. One way is to write a program that will generate the text given an explicit set of rules (Project 2.1.1.1). The second is to create a program that analyzes a text and derives its underlying structure (Project 2.1.1.2). This second approach has an added advantage in that it may yield a partial model of the processes underlying text comprehension.

Project 2.1.1.1: Structural Analysis of Children's Stories and School Materials.

Children's stories would seem an ideal starting point for analysis of discourse. They are relatively simple, and do not make use of esoteric world knowledge. For this reason, children's stories have been chosen for analysis by Charniak (1972), SRI scientists and by Xerox (Winograd, Bobrow). However, it has turned out that even these restricted domains require a great deal of prior knowledge. Important design questions concern how to bring this prior knowledge to bear in analyzing the text (see Charniak, 1972). This research should not only help us characterize the structure of a text, it should also help suggest models of how a person derives semantic information from a text.

Project 2.1.1.2: Computer Generation of Text.

There are two ways to approach the generation of texts by a computer program. First, the computer can be given as input a set of to-be-expressed propositions in some language-free format. The task of the program is to generate a text that realizes these propositions. The critical problem for this program is to meet all the grammatical and stylistic constraints of the language in which the text is generated. A more ambitious approach to computer generation is also to have the program generate the to-be-expressed propositions. To be capable of this creative act, the program must have some model of general constraints on the topic of discourse. Abelson has worked on this latter problem, focusing on the generation of fairytales and western stories.

Program 2.1.2: Development of Text Grammars.

Program Statement

Develop a text grammar having the properties identified in the above Approach Rationale; i.e., it should be semantically based, and the rules of grammar should be stated relative to context including discourse, extralinguistic, and conceptual context.

Program Potential

Principled instructional and remedial efforts in the area of comprehension are not possible now. The knowledge needed to guide such efforts is simply unavailable. A better understanding of the fabric underlying discourse is a step in the right direction. The research on text grammars proposed in this program can provide some insight into the nature and composition of this fabric.

Program Research Considerations

Linguistic research concerned with the development of text grammars will attempt to identify grammatical rules which apply at the discourse level. Such research would include work on presuppositions (Keenan, 1971) and pragmatics (Grice, 1967); work on the extralinguistic factors mentioned above, technically called deixis (Fillmore, 1971; Leech, 1969); work on contextual effects exerted on a sentence by sentences preceding it (Halliday, 1970; Chafe, 1972); and work which explicitly seeks to develop systematic text grammars (Van Dijk, 1973; Gulstad, 1973).

We should pay special attention to projects likely to result in structural representations of texts and text grammars which may be used by psychologists to study discourse comprehension, and by computer scientists involved in text analysis and language understanding systems.

Program 2.1.3: Comparative Analysis of Texts.

Program Statement

Develop systematic procedures for comparing texts or classes of texts and develop a taxonomy of text types.

Program Potential

The development of formal procedures for comparing texts and the development of taxonomic systems for texts are both important to research on discourse comprehension. For example, in current research on prose learning, one investigator will work with descriptive texts such as encyclopedia articles, while another works with narrative material. Until the selection of text material is more systematic, we will not be able to compare the results of studies that used different texts.

The problem of text similarity also appears in research on transfer and interference involving semantic information acquired from text. Research in this area cannot proceed until procedures are available for specifying precisely what relationship exists between two texts. Such a specification might take the form of rules which could be applied to one text to map it onto the other.

The problem also has important applications in the design of sequences of texts used in instruction. This is especially true when we need to maximize the transfer of semantic information acquired from one text to that acquired from the next text in the sequence.

Program Research Considerations

As we develop procedures for the structural analysis of texts, we could apply them in comparing different texts. For example, once we have specified the semantic or propositional structure of two texts, it is possible to specify at the semantic level the ways the texts are similar. At the semantic level, we can consider two kinds of similarity: similarity in lexical content and similarity of structure. The two texts can also differ in the particular grammatical transformations applied to generate the surface structure of the texts.

It is much harder to describe in detail the problem of text taxonomies. Certainly the considerations involved in comparing texts are relevant to this problem, but it is also possible to approach this problem at a global level. For example, such intuitive distinctions among texts as "narrative," "descriptive," and "persuasive" might be developed into a systematic taxonomic system. Most work on this problem appears to be in such fields as folklore, rhetoric, and criticism.

APPROACH 2.2

MEASUREMENT OF THE KNOWLEDGE ACQUIRED WHEN WE UNDERSTAND TEXT

Approach Statement

Develop procedures which employ an analysis of the text structure as a basis for measuring the semantic and structural information listeners or readers acquire when they understand the text. Using these procedures, determine what the relationship is between the semantic information contained in a text and the semantic information subjects acquire when they listen to or read the text. (This approach is strongly related to the assessment issues considered by Panel 5.)

Approach Potential

There appears to be a general consensus among a number of linguists, computer scientists (see references under the previous approach), and psychologists (Fredericksen, et al., in press; and Meyer, 1974) that texts are derived from semantic networks or sets of interrelated propositions. A number of detailed models of text structure are already well developed. It should be possible to use them as a basis for assessing semantic information acquired from text. Investigators have already developed the necessary procedures for coding reproduced semantic information in recall of discourse (Fredericksen, et al., in press; Meyer, 1974; and Crothers, 1972) so progress in this area should be very rapid. The most serious problems appear to be in analyzing information in subjects' protocols which does not reproduce text content. Comparisons of such derived semantic information with a representation of a presented message should provide valuable information concerning the mental operations subjects apply in understanding a message and generating their own acquired knowledge.

Further development of probe recall techniques to assess comprehension is important also and is likely to continue to be productive, especially when probe techniques are considered together with chronometric analyses of response latencies.

In terms of immediate importance, it might be more fruitful to apply to children's stories the sophisticated recall analyses of Fredericksen, et al. (in press) and Meyer (1974), which were developed for adult textual materials (e.g., Scientific American articles). Success here would have immediate educational implications.

Approach Rationale

A fundamental question is just what semantic or logical information listeners or readers acquire when they listen to or read textual materials. If one had available a detailed model of the semantic content of a text, and if one had available a detailed representation of the knowledge a subject had acquired from a text, then one could examine the relationship between the two structures. There is reason to believe that information in subjects' knowledge structures is of two sorts: information which reproduces the content that was read or heard, and derived information which does not reproduce that which was explicit but relates to the content (Bransford and Franks, 1971; Fredericksen, 1972, 1975ab). Two questions in trying to characterize the comprehension process are: (a) What information and how much information presented in text do people incorporate into their memory structures? and (b) What sorts of derived information do they acquire? The answers to these questions should add much to our characterization of the mental operations involved in comprehension. Thus, by comparing a model of a person's knowledge structure (inferred from one of the assessment procedures to be described) to a model of a text, we should be able to reconstruct the processing operations people apply to an input text to generate the semantic information contained in their knowledge structure.

Division of the Approach

There are three ways to attack the problem of measuring semantic information acquired from text. The first and perhaps most direct method involves obtaining responses from subjects by means of tasks such as free recall, meaning reconstruction, precis-writing, and question-answering (in which the recall of whole structures is assessed). Note that these measures resemble those used in educational situations and therefore have ecological validity for classroom learning and assessment. The primary advantage of free recall over other procedures is the rich and possibly exhaustive source of information it provides concerning the subject's memory for text. Recall measures also may be preferred because they do not necessitate the use of probes. The probe can seriously complicate the assessment of memory structure by giving people opportunities to generate semantic information in response to the probes themselves. The first program, therefore, stresses the importance of using free recall of content and a method of scoring which is derived from the structural analysis of the text.

The second program advocates alternative measures of assessing memory structure for text, all of which add structural information in the form of questions, probes, etc. It capitalizes, however, on the sophisticated models developed recently for using reaction time measures (chronometric models). The third program is related to the second and involves the development of comprehension "tests" suitable for research applications when we want to test large numbers of children.

The last three programs of this approach will use the procedures developed in the first three to investigate individual differences in the knowledge structure acquired from text (2.2.4), developmental changes in memory structure (2.2.5), and the differences involved in processing oral vs. written discourse (2.2.6).

Program 2.2.1: Semantic Analysis of Knowledge "Recalled" from Text.

Program Statement

Develop methods for coding the semantic content of a person's recall protocol. The protocols are obtained using free response tasks, and the coded results are to be compared against the logico-semantic structure of a presented text.

The methods to be developed here are iterative in that initial attempts will be admittedly primitive in theory and will become progressively more refined through development. Again, simple prose materials may be advisable as starting points.

Program Potential

Free response methods (unrestricted recall of the message) provide a direct way of assessing knowledge acquired from text. The difficulty in using recall techniques with prose materials has been that in the absence of a detailed structural representation of the semantic information contained in the materials, it has been impossible to evaluate just what semantic information a person has recalled from a text. Thus, much work in this area has depended on verbatim measures (which do not meet a minimal criterion for understanding--ability to paraphrase a text), recall of "key" lexical items selected from the text, grossly defined "idea units" and the like. It is now possible in research on knowledge acquisition from prose to use network models of text structure as a basis for scoring semantic information in the person's recall protocol. Fredericksen, et al. (in press) and Meyer (1974) have found that reproduced semantic information can be reliably scored when a network representation of a text is used as a template against which to score a subject's text recall. Some manuals for scoring are available. Other levels of analysis, though not as detailed, are also in use. In short, we advocate the use of a well-defined, theoretically based scoring scheme whenever possible.

Program Research Considerations

Current work on semantically analyzing texts and coding subjects' recall of text against a network representation of text structure could develop further in three areas. The first is concerned with the development of computer representations of recalled knowledge as data structures and the development of computer programs to operate on these data structures (Project 2.2.1.1). The second involves the

application of these procedures to the study of derived semantic information in a person's recall of the text (Project 2.2.1.2). What is needed is a detailed examination of the nature of derived information and the relationship it bears to semantic information explicitly represented in the text. The third involves examining interresponse dependencies as a basis for inferring what semantic units are processed as wholes (Project 2.2.1.3).

Semantic networks are normally represented as data structures in computational linguistic work and simulation models. We would like to be able to represent a person's knowledge of particular topics as data structures. These data structures would permit detailed analyses and comparisons of peoples' knowledge of certain topics and facilitate computer analysis of data (Project 2.2.1.1).

In addition to studying the level of recall of items of information from the semantic structure of the text, it is possible to study interresponse dependencies. If a set of items is found to be mutually dependent (i.e., positively correlated in an item analysis), it would indicate that the items form a single functional processing unit. It is reasonable to expect to find units corresponding to propositions or even aggregates of propositions. Studies of inter-item dependencies are few (see Crothers, 1972; Anderson & Bower, 1973; Fredericksen, et al., in press); but the suggestion is that items are not independent and that their mutual dependence is patterned in a way related to the propositional structure of the text. Results from studies of text recall and of structural factors producing these dependencies would have obvious significance for the design of textual materials for use in instruction (Project 2.2.1.3).

Project 2.2.1.1: Computer Representation of Recalled Knowledge Structures as Data Structures.

Develop a computer model for analyzing and representing edited recall of text by high school students.

Project 2.2.1.2: Analysis of Derived Semantic Information in Text Recalls.

The nature and importance of this project has already been described.

Project 2.2.1.3: Functional Processing Units in Semantic Structures Acquired from Text.

Develop an item analysis method for showing how propositions acquired from reading a text are interrelated. High school students may be ideal persons to use as subjects.

Program 2.2.2: Development of Chronometric Models that Test the Meaning Representation Derived from Text.

Program Statement

Develop probe recall, question-answering, sentence recognition, sentence verification, and other methods for assessing semantic information acquired from text in reaction time studies.

Program Potential

Analysis of errors and response time measures obtained from choice-response tasks such as verifying whether a sentence is true or false have been successfully applied in research on single sentences. The concern has been to discover the form in which the sentences are represented in memory. The resulting chronometric models provide a description of the sequence of mental operations which access and use a memory structure. Chronometric techniques have also been applied to the study of structural aspects of word meanings or lexical information in long term memory by measuring the time it takes to verify statements such as "A canary is a bird," as opposed to "A canary has wings." Chronometric models, thus, can be used to investigate mental processes and memory structures.

In research with text, it would appear that chronometric techniques together with the analysis of errors in sentence recognition, sentence verification, and question-answering can potentially add much to our understanding of the form in which information acquired from text is represented and organized in memory. However, as a means for assessing a subject's complete knowledge structure, these methods are less appropriate than the methods described in Program 2.2.1. (See Panel 1 on semantic memory, Program 1.1.1.)

Program Research Considerations

Chronometric models indirectly contribute to our knowledge about parsing, i.e., how the internal representation is derived. The representations suggested by the processing models define the endpoint of the parsing process. Thus, they serve as a way of delimiting some of the unknowns in parsing.

Program 2.2.3: Application of Explicit Models of Text Structure to Development of Tests of Comprehension.

Program Statement

Develop comprehension tests for use in large-scale testing applications. Test developers would draw from a model of text structure and the information obtained in Programs 2.2.1 and 2.2.2 to construct

multiple-choice items to assess the semantic information acquired from text. Such instruments could be used in large-scale attempts to determine what sorts of semantic information various groups of children acquire when presented with written or spoken texts. To the extent that such instruments are based on results obtained in Programs 2.2.1 and 2.2.2, the gap between "basic research" and application could be substantially reduced.

Program Potential

This program provides not only the potential of very early success in constructing better tests, but also the advantage of having tests directly reflecting advances in our understanding of the basic processes in text understanding.

One further benefit of the research outlined under this program would be that achievement tests could provide more information about precisely how children differ in the kind and amount of semantic information they acquire from a passage. Thus, systematically constructed tests ought to have diagnostic value as well as permit global comparisons to test norms. The development of theoretically based comprehension tests is critical to implementing the shift from "norm-referenced tests" of comprehension to "criterion-referenced tests" advocated in the Miller Report (Miller (ed.), 1974). In testing terminology, comprehension tests so constructed ought to have greater construct validity, where the notion of "construct validity" will have been precisely defined in terms of a model.

Program Research Considerations

Following the suggestion that achievement test items be systematically constructed using principles of transformational grammar, it has been argued that achievement test items be constructed using a model of the semantic structure of the text on which the items are based. The current status of research on this suggestion is deplorable. It would appear that enough is known now to begin designing achievement test items systematically from semantic representation of texts, i.e., propositions. As more is learned about the basic processes in discourse comprehension (especially under Programs 2.2.2 and 2.2.3), these results can be applied directly in constructing comprehension tests for large-scale applications.

Program 2.2.4: Individual Differences in Knowledge Structure Acquired from Text.

Program Statement

Determine what order of quantitative and qualitative variation exists among individuals across age, language, social, and cultural groups in the kind and amount of semantic information acquired when a discourse is understood.

Program Potential

As the procedures described in Programs 2.2.1 - 2.2.3 are developed, they can be used to investigate the manner and extent to which individuals differ in their knowledge structures for text. Because assessments are made at the semantic level, important comparisons across linguistic groups ought to be possible.

Project 2.2.4.1: Criteria for Indicating Proficiency in Comprehension.

Identify criteria which can be used to identify individuals who are more effective or proficient in understanding discourse.

Project 2.2.4.2: Cognitive Characteristics Related to Comprehension.

Identify cognitive and other characteristics related to discourse processing in children.

Program 2.2.5: Developmental Changes in Memory Structure.

Program Statement

Identify developmental changes in the semantic information children acquire from oral and written text, including ordered developmental sequences associated with complexity orders in semantic structures. (See Panel 1, Program 1.3.3.)

Program Potential

Given a well-defined model of text structure and procedures based on such a model, research on developmental differences could follow rapidly.

If the developmental changes associated with age can be clearly identified, then we could develop a technology for writing texts which differ in complexity according to the cognitive abilities of children at different age levels.

Program Research Considerations

The primary interest of this program is to obtain detailed information concerning both the types of semantic structures children are able to acquire from text and the effects of grammatical structures on the acquisition of semantic structures. The emphasis should be on studies capable of providing information concerning changes which take place in the ability to understand specific kinds of semantic information.

Project 2.2.5.1: Acquisition of Semantic Structures.

Determine the order of acquisition of semantic structures in discourse comprehension by children.

Project 2.2.5.2: Acquisition of Semantic Structures in Learning to Read.

Determine the order of acquisition of semantic structures in learning to read and compare the results obtained to studies of oral discourse comprehension by children.

Project 2.2.5.3: Cognitive Development and the Acquisition of Semantic Structures.

Determine the relationship of ordered cognitive development to order of acquisition of semantic structural information in children's understanding of oral and written discourse.

Project 2.2.5.4: Acquisition of Semantic Structures in Second Language Learning.

Determine the order of acquisition of semantic structures in second language learning, and in learning to read in a second language. Compare this order with that of first language learning. (See also Approach 2.5.)

Program 2.2.6: Oral Comprehension and Reading Comprehension.

Program Statement

Determine in what manner spoken discourse is processed differently from written discourse, and in what way knowledge acquired from spoken discourse is different from that acquired from written text.

Program Potential and Research Considerations

We feel that this program should be construed as a separate approach. It is inserted under this approach solely to avoid repetition. That is to say, any of the approaches, programs, and projects already considered can involve the use of spoken or written text. The principal objective in comparing comprehension of written and spoken text should be to develop an understanding of similarities and differences in those information-processing operations involved in reading or in listening. The comparison, however, is not so simple; a number of not so obvious characteristics differentiate a spoken text from a written one.

Finding important differences is only a first step. The essential characteristics of spoken or written text must not be destroyed in the attempt to compare them. Texts identical except for the modality of presentation may have different effects on listeners or readers if (for example) the spoken material is atypical of the kind normally encountered.

APPROACH 2.3

EFFECTS OF TEXT STRUCTURE ON DISCOURSE PROCESSING

Approach Statement

Determine how the structural characteristics of texts influence how the texts are processed and what knowledge is acquired.

Approach Potential

The question the present approach addresses concerns the very nature of text comprehension and the manner in which text characteristics affect text processing. Thus, the information gained in this research is likely to be extremely valuable, both to our understanding of processing in the linguistic communication of knowledge, and to the practical problems associated with the design of textual material that communicates effectively. While the approach may require a long-term enterprise, it is reasonable to expect that many of the results obtained would have immediate, practical value.

Approach Rationale

When individuals listen to a text, they hear an ordered sequence of speech sounds from which they are able to synthesize a "surface" text: an ordered string of words marked off by grammatical notation. When they read a printed text, they see a string of orthographic symbols from which they are able to generate a surface text. From this, they are able to acquire both conceptual and structural information which link text concepts with those already stored in memory.

The process of extracting information is not as simple as it might at first seem. When people understand a text, they do more than passively extract information from the surface text. Sentences embedded in texts are analyzed with the help of both grammatical rules and the linguistic and nonlinguistic contexts in which they occur. Thus, it is important in research on language processing to avoid the pitfall of assuming that results obtained at the single sentence level will be valid at the discourse level. This approach, then, recommends that basic research on effects of text structure, both grammatical and semantic, be conducted at the level of the text or connected discourse.

Approach 2.3 therefore requires a structural model of text (see Approach 2.1) consisting of (a) a propositional (semantic) base structure for text, and (b) a grammar capable of generating a text and its paraphrases from a single propositional base. Effects of

structural variables on semantic knowledge acquired from text will be investigated as a way of studying the processing operations which result in such knowledge. In this approach, the methods described in Programs 2.2.1 and 2.2.2 can be employed to assess acquired semantic knowledge. "Acquired knowledge" should be understood to include all information subjects acquire when a text is "understood," including information not derivable from a text by means of an application of purely linguistic rules. Such information would certainly include inferred knowledge.

Of special interest to this panel are the effects of the context in which the text occurs. Although it may not be possible to separate the discourse from the context in which it occurs, this panel judged contextual factors to be so important that the study of contextual effects on discourse processing is treated as a separate approach (Approach 2.4).

Division of the Approach

Discourse can be analyzed into several levels of structure: the semantic or propositional structure, the surface structure of individual sentences generated from the propositions, and the surface structure which cuts across sentence boundaries, e.g., topical organization, staging, and distinctions between old and new information. Because any study of text structure which fails to consider all levels of structure is incomplete, and because these levels interact and influence one another, the panel decided to propose a single, unified research program--instead of the several programs characteristic of previous approaches. We, thus, intend to emphasize the interdependence of projects in this approach. We recommend that funding decisions in this area favor programs designed to investigate several levels of discourse structure.

Program 2.3.1: Effects of Semantic Structure on Semantic Information Acquired from Text.

Program Statement

Determine effects of semantic structural characteristics of text on the semantic information acquired when a text is understood.

Program Potential (See 2.2.1)

This program seeks to overcome limitations of prior psycholinguistic research on single sentences without context, limitations discussed in Approach 2.1. The conception which appears to be developing of linguistic structure at the discourse level may be thought of as a production system consisting of several levels.

The first level involves the selection by the speakers or writers of a network of semantic representations for communication. A second

stage involves "staging"--determining the order in which the semantic representation is to receive surface expression, the topic-subtopic structure, and the transformation of the semantic structure into sentences and clauses. The final level involves the application of grammatical rules to the already semantically "chunked" information.

These different levels of structure presumably have different effects on the comprehension process. It should be possible to isolate and understand the effects through appropriate experiments. The results should add to both our understanding of the comprehension process and our knowledge of the factors affecting the comprehensibility of textual materials.

Program Research Considerations

The focus in this research is on the variables that may be identified via the structural analyses generated under Approaches 2.1 and 2.2. That is, once we have succeeded in identifying the propositions and their relations (semantic structure) in a text, along with a set of grammatical rules to generate surface text, we could then vary these in an effort to find out which variations best facilitate comprehension. This experimentation could occur either in parallel or following Approaches 2.1 and 2.2. However, such work is usually best done after the analytical and theoretical analysis of the text has progressed somewhat.

Project 2.3.1.1: Effects of Text Connectedness and Organization.

Explore quantitative measures of text connectedness and organization; determine if this organization can be divided into levels, e.g., a hierarchical structure versus a list structure for propositions. Then investigate how well understood or remembered is information located in tight versus loose structure, in high versus low levels, etc.

Project 2.3.1.2: Effects of Semantic Structure and Lexical Content.

Systematically vary the semantic structure and lexical content of a text and assess its effect on comprehension. It has been shown, for example, that sentence recall depends more on the number of propositions than on the number of words. Meyer (1974) showed that the location of the proposition in the hierarchical structure is critical to recall of the information.

It is important in this work not to confuse the propositional structure of a text with other nonsemantic characteristics, e.g., topic-subtopic organization. Thus, it is important that relevant experimentation be based on an explicit model of the propositional (network) structure from which a text is derived. Previous work has often suffered from either a lack of an explicit propositional model or a tendency to confuse the topical organization of a text with the semantic structure of the propositional base.

Project 2.3.1.3: Effects of Varying the Type and Amount of Information Explicitly Encoded in Text.

Given a propositional network, generate texts from the network. Vary the type and amount of information from the networks explicitly encoded in the text. Study the effects of such variations on the semantic information acquired from these texts.

It has been established that knowledge acquired from text often includes information not directly expressed in the text (Bransford and Franks, 1971; Fredericksen, 1975 a, b). If the generation of such information is a process fundamental to text comprehension, then it is natural to study this process. In particular, it is important to study the effects of the variations described above. There may be an optimal amount of explicit coding which depends on factors such as the nature of the deleted information and the relationship of this information to the subject's knowledge of the world.

Project 2.3.1.4: Semantic Complexity.

Examine what is meant by "semantic complexity." Here, one could vary either the number of propositions, the complexity of propositions, the degree of embedding, or the ways in which the propositions are connected (Fredericksen, 1975 c). In fact, there is no existing clear definition of what we mean by the complexity of meaning structures. Syntactic and linguistic complexity each contribute to difficulties in understanding language. Syntactic complexity has a relatively clear definition in certain grammars; semantic complexity has been defined in semantic feature theory (Fodor and Katz, 1964) though it has not yet been explored with respect to semantic networks. This idea should be extended to an analysis of text and could lead to well defined indexes of text complexity.

Project 2.3.1.5: Derivation of Word Meaning.

Study how the meanings of individual words are derived in the context of texts having different structures. Individual words (as well as sentences) are highly ambiguous in meaning. The context of a sentence and other related sentences aids in inferring the intended meaning. This project may yield information useful for designing texts which facilitate vocabulary growth without the use of a dictionary. It may also lead to better teaching methods for encouraging vocabulary growth.

Project 2.3.1.6: Choice of Words in Text.

Study the effects of choice of words on the communication of semantic information.

One of the first processing steps in the production of discourse is the decision as to what words to use to represent given concepts. For example, an action may be represented by means of a single word (e.g., walk) or by a set of words (e.g., move oneself from one location to another by moving the legs at a certain rate, etc.). This process is fundamental to speech and other cognitive activities.

Project 2.3.1.7: Surface Organization of Semantic Information in Text.

Study the effects of expressing propositions within and between sentences; study the effects of other "staging" variables such as topic-subtopic structure on semantic information acquired from text.

Propositions are units of semantic structure; sentences are units of surface structure. The process of generating a text from a propositional network involves decisions concerning what units are to be expressed within sentences. Propositional units are likely to be important to semantic processing and surface units are likely to be important only to the interpretive processes which generate semantic structures from surface sentences. The manipulation of such "surface units" is relevant to the determination of the role and importance of interpretive versus semantic processing in discourse comprehension. Similarly, the topic-subtopic structure is a characteristic of the surface structure of a text which determines the order and manner in which semantic information is expressed in text. Comparing different topical structures for a given propositional structure is also important to the above determination.

Project 2.3.1.8: Variation of Syntactic Complexity Within a Text.

Examine whether syntactic complexity is critical when varied in a text. We know that syntactic complexity influences understanding and recall of single sentences. The question is whether this makes any difference when the sentence can be understood in the larger context of other sentences.

Project 2.3.1.9: Syntactic Complexity and Propositionally Based Text Grammars.

Previous research on syntactic complexity in comprehension needs to be reinterpreted in terms of propositionally based text grammars (including discourse-level processes such as "staging"). From this perspective, syntactic complexity is determined by inspection of the rules used to generate sentences from propositional information. We assume that the propositions to which the rules apply have already

been marked for order of expression, units of expression, and other staging decisions. One way to measure syntactic complexity is in terms of the number of decisions required to parse a text into its semantic structure.

Project 2.3.1.10: Other Organizing Elements.

There are many other organizing elements in discourse that are neither logical nor semantic. There are "rules" for stressing old or new information, what the theme or topic is, and what the comment is on the topic, etc. These general discourse rules have been discussed by linguists (e.g., Halliday, 1970) but their importance has not been systematically assessed. Perfetti has looked at interactions of topic with sentence complexity and has demonstrated overriding effects of topic. We need more work here on how comprehension is affected by these linguistic factors.

APPROACH 2.4

KNOWLEDGE GROWTH AND USE

Approach Statement

How does linguistic knowledge grow and how is this knowledge used to understand discourse?

Approach Potential

An adequate account of the processes involved in understanding written and spoken instructional materials should include the following three types of considerations: (a) What is the form of the reader or listener's "knowledge of language?" (b) How is this implicit knowledge used to achieve understanding? (c) What does it mean to understand? It is important to view these questions from a developmental perspective. One's "knowledge of language" is continually evolving. We ask how its form at any stage of development affects comprehension. Moreover, we ask how experiences with language shape the form of linguistic knowledge. This knowledge is necessary to design effective means for teaching essential language skills. Most importantly, the contextual conditions under which children (and many adults) use noninstructional language to understand may be quite different from the conditions involved in understanding instructional materials. If so, gaps in the types of skills and knowledge necessary to understand such information may exist. Furthermore, various social groups may develop different linguistic skills and knowledge depending on the types of social conditions under which their language is normally used. Their abilities to use language will undoubtedly be well adapted to the purposes for which they use it, but they may not be adapted to the particular uses of language required in formal educational tasks.

Approach Rationale

In recent years, research from three disciplines has converged on the idea that understanding involves more than mere "linguistic knowledge." In linguistics, researchers have discussed the importance of extralinguistic beliefs and presuppositions in determining the grammaticality of utterances (e.g., Fillmore, 1971; Lakoff, 1967, etc.). In the artificial intelligence literature, models of language understanding have had to incorporate "knowledge of the world" (e.g., Schank, 1972; Winograd, 1971). Psychologists who have manipulated the contextual support for passages have found comprehension of text to be profoundly affected by such nonlinguistic contexts (e.g., Bransford and Johnson, 1973; Dooling and Lachman, 1971). In addition,

sentences that are comprehensible in isolation (i.e., comprehended without contextual support) can be shown to involve extralinguistic assumptions necessary for the person to make sense of them (e.g., Bransford and McCarrell, 1974). Thus, while "knowledge of language" in the sense of linguistic competence undoubtedly plays a crucial role in comprehension, such knowledge by itself is not sufficient to insure comprehension. People use their implicit linguistic knowledge in order to understand discourse. We do not deny that adults understand sentences in isolation at some level. But the ability to do so presupposes the availability of certain skills and knowledge that comprehenders must generate on their own.

The fact that extralinguistic or contextual factors influence understanding becomes especially significant when viewed from a developmental perspective. Initial language usage occurs in social contexts. In such cases, a great number of contextual cues are available. The identity of the speaker, spatial and temporal factors, etc., are all specified. Given these conditions, one can use a very impoverished knowledge of language and understand what a speaker means. In fact, one can argue that initial language learners may be so responsive to or dependent upon contextual constraints that they rely mainly on them to understand what a speaker intends by linguistic and nonlinguistic actions rather than rely upon stored linguistic knowledge. They then use their understanding of these contextual aids to figure out and learn the meaning of the linguistic utterance and to crack aspects of the syntactic code. (See MacNamara, 1972, and Nelson, 1974.)

One could view language development as going from dependence upon external, concrete situations to a greater reliance upon abstract, internal knowledge. We would call this process, "decontextualization." The basic problem for the language learner is to learn to interpret what is said or written in the absence of the immediate referents. It may be the case, however, that external contexts facilitate all language comprehension and we never escape the importance and use of context.

Note that reliance on social context to figure out what a speaker must mean suggests that listeners' knowledge of language may be sufficient to understand under certain conditions, but may not be adapted for efficient functioning under other conditions of language usage. That is, language is context bound. (Here, we define context to be nonlinguistic in nature, a meaning quite different from that intended in Approach 2.3 where context was linguistic, i.e., other sentences in a connected discourse.) We have frequently assumed that children "acquire language" before entering the school system, but this assumption requires careful evaluation in light of the contextual dependency of language indicated in this approach. Unless we know the particular social conditions under which children use

language, we cannot make such an assumption. They may communicate effectively, and yet be unable to understand given conditions of language usage in formal, educational tasks. (See Approach 2.5 on social differences.)

It is possible that language development involves the acquisition of several strategies by which one can learn to interpret what is said without depending upon context. Among such decontextualization strategies one might list the following: questions (e.g., What is the name of __? What does X mean?), defining in other words, organizing via use of stored knowledge, etc. The whole process of decontextualizing may be that of constructing a store of semantic information from particular instances which can be used to interpret new utterances. The study of heuristics by which we set up and use such internal knowledge stores is central. An educational program sensitive to the process of decontextualization would aim at providing prior experience to allow subsequent language description and comprehension or the use of text that takes into account the child's own experience.

Consider some studies of comprehension in social contexts (cf. Bransford, McCarrell, and Nitsch, in press). In these studies, speakers simply walk up to friends and say things like "paper," "Bill has a red car," etc. In all cases, the listeners seemed extremely perplexed by the utterances. They know what was said, but not what was meant. In a social context, listeners spontaneously assume that utterances have some special significance relative to the present situation or their past knowledge that they share with the speaker. For example, listeners assume that "Bill" refers to a person that they themselves know. Note that the concern is not with understanding the sentence itself (for example, when one asks "Is Bill has a red car an acceptable sentence?"). Instead, listeners spontaneously attempt to understand the meaning intended by the speaker. When contextual conditions are appropriate so that listeners do understand, their experience involves more than an understanding of the sentence per se.

Consider a further aspect of social communication. How often are we confronted with feelings of anomaly like those experienced in the above examples? Such situations do occur, but their frequency is extremely low. This suggests that adults are facile in monitoring their conversations. They follow certain rules of social conversation (e.g., see Grice, 1967) and spontaneously take into account the knowledge of their listeners. It follows that adults may implicitly structure their utterances in order to be relevant to the immediate social and personal contexts of children. If so, children may be able to understand in those contexts and yet fail to understand in the context of more nonsocial, instructional tasks.

Division of the Approach

The preceding considerations warrant careful theoretical and experimental investigation. They suggest that the types of skills necessary to understand instructional materials adequately may involve very specialized modes of dealing with language. The ability to understand linguistic information in situations removed from everyday experience may presuppose a particular knowledge of language that can only be shaped in the context of certain actions or performatory activities. Different learners may have had very different experiences depending on the conditions under which they have used language. The form of their linguistic knowledge may be ideally suited to these conditions, but it may not be so suited to the conditions presupposed by formal education tasks or teachers. This suggests the importance of two very general programs or orientations toward the problem:
(a) to assess and teach the types of linguistic skills and knowledge necessary to function in the formal instructional contexts; and
(b) to re-evaluate the conditions of formal instruction and move them toward the ecological conditions under which understanding occurs more readily.

Program 2.4.1: Comparison of Language Comprehension in Formal (Abstract) Situations to Contextually Rich Ones.

Program Statement

Assess the degree to which listeners can understand language in situations that approximate those necessary to learn in formal educational tasks.

Program Potential

The degree to which students' language understanding depends upon some experiential, contextual support is of the utmost importance. We may think that they understand, and, yet, we may have failed to communicate. Children must learn to decontextualize, to understand despite the fact that they have no immediate experiential base to aid in understanding. These latter skills are necessary for following relatively abstract lines of argument and for reading many styles of text.

Program Research Considerations

When one attempts to communicate general ideas, it is important to understand the processes involved in contextualization; that is, how one structures experience in order to facilitate understanding. When the purpose is to shape students' knowledge of language, one must find ways to keep them from an overdependence on contextual support. An example of a heuristic for overcoming lack of context is found in attempts to have computers learn chess patterns

(Chase and Simon, 1973). Here, the program must use what it knows to make guesses about the problem in the absence of any other external information.

There is evidence to suggest that children's abilities to understand language are heavily context-dependent in ways analogous to these learning programs. Assume for example, that they hear a sentence like "John stayed in bed because it was raining" and they later paraphrase it as "It was raining, so John stayed in bed." This may appear to indicate a precise understanding of so and because connectives, but this is not necessarily the case. In studies by Pearson (1969), children were presented with sentences like "John stayed in bed. It was raining." (These were presented along with other sentences that contained causal connectives.) Nearly all children inferred causal relations between the sentences, and added the causal connectives in their recall. In short, many sentences are understood on the basis of cognitive constraints rather than on the basis of precise knowledge of and attention to the linguistic forms themselves.

Research by Olson (1972) also deserves serious consideration in this context. He found that young children can verify active sentences against pictures, but when verifying whether the active and passive sentences are equivalent, they make many errors. Why can they use their knowledge of language to make judgments about perceptual situations, yet fail to recognize the equivalence among the sentences themselves?

Subsequent studies by Olson (1974) suggest some possibilities. He finds that young children can verify that actives are equivalent to passives--but only under conditions where the target sentences occur in a context that makes their meanings more precise (e.g., where they know who the agents are, why they were doing something, etc.). In short, the children can understand that the sentences are equivalent because they specify similar cognitive information. It is not their linguistic knowledge that specifies sentence equivalence. Instead, it is the equivalence of the cognitive, real world events.

It seems plausible that our adult intuitions about intersentential relations (for example) are based on the general skills we have developed. These skills are best described by a problem-solving paradigm: Comprehenders implicitly learn to discover or invent conditions under which the information specified in certain sentences coheres into meaningful events. Our abilities to do this are prerequisites to our abilities to detect the relationships among sentential forms. At some point, we may develop rather abstract, formal criteria for judging such relationships, but these develop from more basic skills.

Project 2.4.1.1: Language Comprehension under Various Contextual Conditions.

Design studies to compare language comprehension in formal situations to comprehension in contextually rich ones. To what extent do findings such as Olson's (1972, 1974) represent the general state of affairs? How are listeners' abilities to use the same linguistic forms (e.g., because, so, if-then, etc.) dependent on their knowledge of the content of the messages? Will different social groups exhibit differential "language" skills depending on their personal knowledge of what sentences are about?

Project 2.4.1.2: Effect of Context on the Interpretation of Lexical Items.

Design studies to evaluate the degree to which listeners' implicit knowledge of lexical items is geared to certain contextual conditions. For example, suppose that children hear "The truck is near the couch." Later, they say "The truck is by the couch." At first glance, it might appear that they did this because of a tendency to use the semantically simpler form "by." But note that the situation described by the sentence makes unnecessary the type of information specified by "near." The word "near" is used in situations where it is important to specify distance. The text situation must require such information in order to assess what children know.

Project 2.4.1.3: Children's Awareness of Their Failure to Understand.

Investigate the degree to which children know when they have failed to understand the intentions of others. There is evidence that children can learn to take the listener's perspective in sending a message (e.g., Piaget, 1954; Flavell, 1968; Krauss and Glucksberg, 1969). However, we need to investigate the degree to which children fail to realize that they have misunderstood a message that a speaker intends. Note that in social contexts, adults may spontaneously structure their utterances so that children can understand simply on the basis of their own personal reference systems. Gradually, children must learn to understand what other speakers mean. Their abilities to do this probably depend on the existence of certain "real world" criteria. For example, assume children are told to do something. When they find themselves unable to carry out the action, they may know they failed to understand. In other situations, however, children may lack any basis for knowing when they have failed to understand. The problem of developing criteria for degree of understanding is a serious one at all levels of language development. Many college students appear to lack such skills and have to rely upon external feedback (such as tests) for information as to where and how they erred.

Project 2.4.1.4: Use of Language in Different Social Environments.

Investigate the degree to which different social environments foster the use of language for particular purposes. To what degree do these uses foster the development of criteria that indicate lack of understanding? To what degree do the uses prompt listeners to concentrate more on the actual message and less on what they think a speaker must mean?

Project 2.4.1.5: Development of Children's Conceptual Knowledge.

Investigate the nature of the conceptual knowledge available to children prior to and during language acquisition. Research by MacNamara (1972) and Nelson (1974) is relevant.

Program 2.4.2: Analyses of the Processes Involved in Decontextualizing Linguistic Knowledge.

Program Statement

Study how students develop the ability to make effective use of language in the context of formal educational tasks.

Program Potential

The introduction illustrates the importance of this program. In addition, it is necessary for the design of effective methods for teaching language skills.

Project 2.4.2.1: Compare the Effects of Formal and Informal Education.

Attempt to determine how the organization of one's lexical and conceptual knowledge is shaped by the demands of formal education. How do various styles of education influence the way people understand? The cross-cultural research by Scribner and Cole (Scribner, 1974; Cole et al., 1972; Scribner and Cole, 1973) is an excellent case in point.

Project 2.4.2.2: Development of the Organization of Lexical and Conceptual Knowledge.

What conditions of language usage shape the evolution of knowledge organizations? (See Panel 1 for further development of this point.)

Project 2.4.2.3: Assigning Appropriate Contexts to Utterances.

Investigate methods of teaching and assessing listeners' abilities to understand and evaluate utterances in nonsocial contexts. We want to know to what extent children consider who might say something (such as, "May I take your order?"), why they are likely to say it, etc. Open story methods of assessing their answers may be used.

Program 2.4.3: Finding Techniques for Understanding Understanding.

Program Statement

Develop approaches to understanding the general problem of understanding, in both children and adults.

Program Potential

There are many ways to facilitate understanding that are intuitively used in social contexts, but are generally absent in written documents. In addition, there are insights into the problem of understanding that are not emphasized in current psychological theory and research. Although many of these insights are imprecisely specified, this should not deter their pursuit. Note, for example, that a prime rationale for building explicit models is that they lead to the discovery of problems not yet considered. One can identify problems from other sources as well. Also, theorists working on the problems of action and perception are developing theoretical models that provide a structure for thinking about, organizing, and generating fruitful research on understanding (McNeil, 1975; Carter, 1973; Bernstein, 1967; Green, 1971; and Turvey, in press). Work on these problems is essential to move instructional practices toward the more ecological conditions under which understanding normally occurs.

Program Research Considerations

It is important to view the particular problem of understanding written materials from the general perspective of questions about knowing and understanding. Failure to view the problem from a broader perspective is similar to a scientist attempting to understand Stonehenge while ignoring information about astronomy, or a Martian attempting to understand an earthling's wristwatch yet having no concept of time. In particular, one must consider the ultimate goals of educational instruction. The goal can be stated as "understanding materials." What does it mean, however, to understand?

Consider some thoughts about "knowing" or understanding. "Knowing" is an activity. It involves "knowledge," but the two concepts are not the same. Dictionaries and encyclopedias contain knowledge, but they don't know anything. People use knowledge in the process of interacting with and understanding the world.

The ultimate purpose of instruction is to help people act effectively. They must use their knowledge in an unbounded number of novel situations. Frequently, they must restructure their knowledge in order to "see" things differently, as in problem-solving and insight. They then have a basis from which to act. The form of one's knowledge affects the degree to which it can be used in certain situations, as is clear from current work on the problem of representing information in memory. Similarly, it seems likely that the uses to which one puts knowledge affect the nature of that knowledge. In short, there is a symmetry between the form or structure of one's knowledge and the uses to which it is put.

In education, knowledge is imparted in the hopes of facilitating "knowing," yet instruction frequently imparts mere objects of knowledge instead of shaping it into instruments to be used. Part of this problem stems from inadequate conceptions of "meaning," and from equating understanding with "grasping the meaning" of a text.

Consider the simple example of reading instructions to assemble something (e.g., a tent). Individuals have not understood unless they can carry out the actions. It is possible to remember the instructions, and even to paraphrase them on a linguistic level, and still have failed to "understand the instructions." And if they do learn to carry out the actions, they will probably be able to put up the tent at later times and transfer to similar problems as well. They will most likely forget the instructions, but that doesn't matter. In fact, an attempt to memorize the instructions could interfere with one's abilities to learn to carry out the acts.

Consider another example of understanding. How do people communicate in academic conversations? Frequently speakers make a statement of some position. People understand the statement. Then the speakers proceed to explain what they mean by providing examples, demonstrations, and the like. Many graduate students note that they have explicitly memorized particularly interesting statements made by professors. Throughout the course of the semester they keep working on those statements to attempt to determine what they really mean. After various demonstrations, examples, etc., they finally come to see their meanings. They learn to "see" problems from the perspective held by the professor.

The notion of learning as the restructuring of one's system in order to "see" from a particular perspective is extremely important. A number of writers have offered cogent insights on this view. Kuhn (1970) for example, argued that one develops a particular perspective on a field by viewing representative problems and problem solutions. One learns to see problems from certain perspectives, and this shapes the future actions one makes. Similarly, Hanson (1970) discussed scientific theories from the perspective of the effects they have on understanding. Information jells into different patterns depending on one's perspective.

Perhaps the most important work to consider in this context is that of deGroot's (1965) studies of chessmasters (see also Chase and Simon, 1973). He showed that chessmasters do not make more inferences than nonmasters; the former literally "see" or interpret the configurations differently. They start on the problem at a higher level. The problem of inferences is really secondary to the problem of the initial apprehension of structure. One has to see the problem correctly in order to make appropriate inferences.

Project 2.4.3.1: Research on Cognitive Support for Comprehension.

Project Statement

Investigate the processes by which cognitive support influences one's abilities to understand. How can one help students "see what one means?"

Project Potential

This project, and the following ones, should aid in developing ways to shape instructional techniques toward the ecological conditions under which learning and understanding normally occur.

Project Research Considerations

A number of researchers have studied the effects of presenting cognitive aids on peoples' abilities to reason. Studies by Riley (1975) and Riley and Trabasso (1974) serve as representative examples: young children fail to comprehend statements and draw inferences about comparative order in problems like "Betty is nicer than Jane; Frances is not as nice as Jane; who is the nicest, Betty, Frances, or Jane?" When children are given spatial aids such as a row of pictures of three girls or are allowed to play with the pictures while being asked the question, they solve the problem correctly. They can order the pictures correctly (Betty, Jane, Frances) and can make transitive inferences (Betty is nicer than Frances). Thus, external, contextual memory aids facilitate understanding where reliance upon language alone does not work.

Project 2.4.3.2: Use of Questions to Facilitate Comprehension.

Study the effects of orienting questions to make people use the information they are reading for particular purposes. Note that this is different from questions designed to tap memory for particular information actually presented.

Project 2.4.3.3: Structuring Texts for Optimal Knowledge Transmission.

Investigate ways to design passages that put people into the mode of using information for particular purposes. Many of the texts studied in educational research are extremely oriented toward the transmission of factual knowledge. Given such an orientation, it is unlikely that things like instructions to image, organize, etc., will have any large effects. Yet it seems obvious that texts can be structured toward more ecological conditions of knowledge transmission. For example, one can write that there is a technique called operant conditioning, that there are certain components to it, etc. On the other hand, one can write, "Imagine that you have this rat; you want to teach it to do X, etc." Why does text designed to teach have to be written in the forms that it is? This raises further questions. How do we know that beginning reading books should be descriptions of experiences? Maybe they should be in the form of instructions necessary to carry out certain acts that children like to do. These sound like purely applied questions, but it is imperative to note that they must be subjected to rigorous experimentation. For example, making a beginning reading text too close to ecological conditions of learning could actually interfere with the development of necessary reading skills. Similarly, college texts too oriented toward specific situations could result in students' inabilities to apply their knowledge in other situations.

Project 2.4.3.4: Models of Acting.

Encourage the development and conceptual application of models of acting and their relationship to perceiving. Work by Bernstein (1967) and Green (1971) (and see Turvey, in press) provides promising frameworks for theories of action. These ideas are being linked to Gibson's notions of "affordances" as that information upon which we act (e.g., see Shaw and Bransford, in press). These theories have important properties. For example, consider Bartlett's (1932) description of what it means to learn to play tennis. He notes that every action of tennis players is, in some sense, novel and depends on the visual information as well as the immediate position of the players before they make their "next move." Their "knowledge of tennis" is in the form of a general "attunement" and could not be in the form of stored, particular "movement traces" lying in some episodic memory. Similarly, the skilled academic expert is attuned to handle all kinds of novelty. Models of action can be used to help us gain insight into what it means to use knowledge in the act of knowing the world.

APPROACH 2.5

BILINGUALISM

Approach Statement

Investigate the linguistic and cognitive characteristics of bilingual populations.

Approach Potential

The areas of bilingualism and bilingual development must be considered as an independent research area. To subsume this area in other approach categories would continue to reinforce the notion that bilingual development is merely an extension of ongoing research in monolingual development (usually described as "the study of language"). The scarcity of data in the bilingual area does not warrant such an idea at this time.

Moreover, given the emphasis in this panel on context, structures, and knowledge of the world, the study of bilingual persons presents a unique opportunity. The bilingual person has two language-knowledge bases which may operate independently, interactively, or conflictingly (Riegel, 1968). If these structures are independent, then instruction in one language may not be comprehended if the requisite knowledge base for interpreting it lies in another culturally determined language base. A systematic study of these issues could be started once one has defined bilingual subpopulations.

Approach Rationale

Presently, there is little available research concerned with important (and large) populations of children who are acquiring two (or more) languages simultaneously within the natural environment. Continued research on the structure and meaning of language has concentrated on monolingual populations. We do not mean to suggest that this information will not be generalizable or relevant to bilingual acquisition. Yet, with the many bilingual-bicultural educational programs now underway, it seems that the need for a more focused investigation of bilingualism will continue. In addition, due to the lack of research in this area, an important aspect of cognitive processes and styles in psychology has been neglected. Therefore, specific research related to bilingual children and their surroundings must be directly pursued.

Although research in this area is scanty, some findings are available. Sociolinguistic studies provide a preliminary descriptive account of bilingual populations in this country. Bilingual populations

are extremely diversified in their use of different languages (Skrabanek, 1970). Nonetheless, there is a large number of children who acquire two languages, although the receptive and expressive levels of the languages vary with socioeconomic status, education, etc. These children seem to improve in both languages, although they are exposed to an educational system primarily English dominated (Carrow, 1971). Unfortunately, educational research on this population tends to show that bilinguals always seem to do more poorly than monolinguals in academic areas (Arnold and Taylor, 1969). Although there are methodological problems, it is a consistently reported result.

An extension of our knowledge in this area should help overcome the implicit notion of an "educational handicap" and identify functional relationships between bilingual repertories, cognitive styles, instructional patterns, and academic performance.

Division of the Approach

Programs have been suggested in response to (a) the lack of information in the general area of bilingualism and its structural characteristics, (b) the notion of transference between languages, (c) possible differences in the information-processing abilities of this population, and (d) the potential importance of cultural (or social) variables that may be interacting within the linguistic systems and comprehension processes.

Program 2.5.1: Linguistic Description of Bilingual Populations.

Program Statement

To provide a comprehensive linguistic description of bilingual populations in the United States.

Program Potential

This basic data should help determine the complexities and scope of the problem area.

Program Research Considerations

Anecdotal information suggests that, within bilingual populations in this country, there are basic linguistic differences operating in both languages (Nedlar, 1971; Lambert, 1972; and Labov, 1972). Dialect research with Nonstandard Black English has indicated linguistic differences within Black populations. This type of work is needed with bilingual populations and with descriptive emphasis in both languages.

Division of the Program

Recent information suggests that there are different levels of linguistic competence across receptive and expressive domains within the languages of individuals identified as bilingual. Therefore, both receptive and expressive domains must be carefully measured. In addition, theoretical formulations of bilingual development have characterized the two language systems as dependent, independent, or interfacing. Descriptive information must yield some analysis of these characterizations by focusing on structural (grammatical and syntactical) and semantic variables within and across both languages.

Project 2.5.1.1: Taxonomy of English or Spanish Comprehension.

An extensive investigation of comprehension abilities of the various types of bilinguals in both languages is needed. This project would ultimately lead to measures for assessing the receptive skill in each language.

Project 2.5.1.2: Taxonomy of English or Spanish Production.

We need an investigation of the productive abilities of various types of bilinguals in both languages. This project would focus on the expressive skill in each language.

Project 2.5.1.3: Taxonomy of English or Spanish Structure.

In order to understand how bilinguals learn a second language we need grammatical and syntactical descriptions of the two languages. Does a knowledge of Spanish interfere with acquisition and use of English because of grammatical differences? In what ways might a structural description of each help or hinder comprehension?

Project 2.5.1.4: Developmental Description of Spanish or English.

We need parallel descriptive investigations of structural and semantic components, lexical items, etc., which arise simultaneously in each language system for children who are (a) expressive in both languages, and (b) receptive in both languages.

Program 2.5.2: Linguistic Transference.

Program Statement

Promote experimental study of language transference in bilingual populations.

Program Potential

The traditional model of linguistic investigation (taxonomy of language) has yielded correlational analyses of language structure with age. A more direct experimental approach in the bilingual area would attempt to go beyond correlational analysis by directly manipulating language parameters in one language while monitoring effects of those manipulations on the other language. The choice of variables to manipulate should entail an analysis of shared semantic structures, each to be expressed in one of the languages. This assumes that the bilingual person is productive in both languages. Paradigms for receptive competence can also be developed using techniques recommended in Approach 2.2. The issues of independence, confounding, or coordination of the language knowledge base can be studied. If, as suggested in Approach 2.4, the contextual basis for the knowledge of each language structure is different, then there may not be any transfer, despite semantic structural similarity at the level of the discourse analysis.

Specific training in language exemplars in one language while directly monitoring similar instances in the second language could also test the transfer in more limited ways, but they may pay off educationally. For example, skill training in a specific transformational type in English might lead to specific transformational effects in Spanish. This method is more likely to produce a useful analysis of bilingual development because it depends on direct manipulation (training) rather than observational correlations. We hope this will allow identification of functionally related linguistic areas in the two languages.

Program Research Considerations

Linguistic transference research must include structural and semantic analysis across the languages in both receptive and expressive domains.

Project 2.5.2.1: Semantic Structural Transfer.

Investigate changes in semantic structural characteristics of one language as a function of structural changes in the other language. This project would teach a new structure in one language system and test for its occurrence in the other. Question: Does the transfer occur without specific training?

Project 2.5.2.2: Lexical Transfer.

Investigate changes in lexical organization (see Panel 1) across languages as a function of change in lexical information in one language

Program 2.5.3: Bicognitive Structures.

Program Statement

The processing of discourse information may take on particular characteristics depending on individual linguistic complexity (defined here as bilingual or monolingual).

Program Potential

This program fosters process studies on bilingual persons such as those studies recommended in Approaches 2.2 and 2.3 using materials developed in Approach 2.1. Studies of cognitive structures and processes within which bilinguals function would be novel. The information-processing systems used by bilinguals and the acquisition of these processes are of both theoretical and applied interest. Understanding of basic cognitive functions might account for performance differences now cited in available experimental reports. Educational strategies may be modified as a function of this research.

Program Research Considerations

Ramirez' work in this area has concentrated on bicognitive analysis of educational related systems with Mexican-American and Anglo-American children. This type of research should be encouraged. We want to know if these cognitive styles change as language dominance, dependence, or independence changes. The considerable advances made in cognitive psychology since Neisser's (1967) book and the resulting set of models, methods, etc., for memory, perception coding, etc., provide a rich source of ideas and techniques for investigating cognitive processes within a bilingual person (Cole and Bruner, 1971; Cole, Gay, Glick, and Sharp, 1972; Cole and Gay, 1972).

Project 2.5.3.1: Bicognitive and Bilingual Independence.

Investigate whether there are cognitive structures and processes that are independent of linguistic and/or cultural characteristics. (See Furth's book on the deaf, 1966; also Cole, Gay, Glick, and Sharp, 1972.)

Project 2.5.3.2: Transfer of Learning.

Examine the transfer of learning and information in one language to another language using experimental situations in which the cognitive skills required (e.g., rehearsal in free recall, imagery, etc.) are under the subject's control.

Program 2.5.4: Cultural Variables.

Program Statement

Encourage analysis of the interdependence of culture and language within a bilingual person.

Program Potential

Sociolinguistic approaches to language acquisition have emphasized the interaction between language and the social (cultural) environment. Approach 2.4 suggests that language depends upon particular contexts. One's language knowledge, if uniquely associated with social context, may not transfer to another linguistic system. One could use dichotic listening studies to see if concepts in one language influence linguistic interpretations in the other language. We encourage bilingual acquisition studies. We should consider cultural variables which may well be involved in language differences. Background factors of importance include patterns of child rearing, differential communicative styles, language socialization, selective attention, cross-cultural encoding and decoding, the role of silence and/or nonperformance.

Program Research Considerations

Sociolinguistics is a domain within general linguistics which seeks to study the structured interrelationship between language (both as code and behavior) and social life. In this country, sociolinguistic research has been oriented strongly in the direction of correlational studies using both small samples (e.g., Fischer, 1958; Labov, 1963) and large heterogeneous samples in urban communities (e.g., Labov, 1966). The research design in each of these studies focused on the correlations between selected linguistic variables and an array of nonlinguistic or sociological variables, such as stylistic context, social class, age, sex, ethnic groups, etc. Other sociolinguistic studies focused on the linguistic features of Nonstandard Black English (e.g., Labov, et al., 1968; Wolfram, 1969; Anshen, 1969; Labov, 1972). Studies directed at Spanish-English bilingualism (Fishman, et al., 1971) or linguistic assimilation (Wolfram, 1973) in the Puerto-Rican community need to be encouraged in the future.

Project 2.5.4.1: Social Context Analysis of Spanish and English Usage in Natural Settings.

Identify social context variables influencing development, maintenance and destruction of bilingual repertoires.

Project 2.5.4.2: Linguistic Style Analysis of English and Spanish Usage at Home and at School.

Analyze language usage specific to styles used in formal education and non-formal educational systems.

APPROACH 2.6

MODELS OF THE PROCESS OF EXTRACTING MEANING FROM DISCOURSE

Approach Statement

Develop models (primarily computer-based) simulating the psychological processes involved in extracting meaning from a discourse.

Approach Potential

This approach focuses on that part of the communication system where listeners or readers receive the discourse and must derive their own understanding of it. This process is extremely complex and defies description by theoretical methods such as mathematical or physical models. The complexity, however, is within the capacity and power of modern computers. This approach naturally complements ongoing theory and research in other areas. The following are contributions we might expect from work with computer models:

1. The research serves to test the consistency and completeness of theories. If the theory is not consistent and complete it will not run as a computer program. A worthwhile example involves large handwritten transformational grammars. These systems were found to have hidden inconsistencies only when simulated on a computer (see Friedman, 1971).

2. Computers allow one to explore the dynamic interaction of complex processes and their products (here, derived representations of meanings). Often this is the only way to derive empirical predictions from complicated theories. Thus, a computer model plays an essential role in the experimental testing of theories of language understanding.

3. The simulation of a process can be heuristic. It suggests problems that might not otherwise be foreseen or detected.

Approach Rationale

Initially, the problem of the computational handling of natural languages was treated as largely a question of syntactic analysis. In the early years, most work concentrated on developing grammars that would be useful for parsing and generating English sentences. Recently, researchers have shifted toward an emphasis on the problems of semantic representation. Artificial intelligence researchers have realized that they must develop meaning representations consistent with the use to be

made of these representations. Syntactic deep structures or other syntactic structures do not, for most uses, meet this requirement.

There are some very impressive language-processing programs in artificial intelligence that work in restricted task domains. Many of these programs have achieved their success by very careful analysis of the information-processing demands of their task environment. Algorithms incorporating these demands are built. However, because the programs are so focused on a particular task, they tend to be difficult to extend; and, thus, do not clearly contribute to general theoretical development.

We should emphasize the study of processing mechanisms that generalize to a wide range of phenomena. Program generality is a major concern if it is to be a useful predictive device. Newell and Simon's production systems constitute a prime example of an attempt to develop such a general system. (See Newell and Simon, 1972.) This system incorporates psychological memory assumptions based on psychological models and data outside artificial intelligence, and, therefore, has direct psychological relevance.

The generality and power of a program must be disciplined by the incorporation of considerations about psychological reality. The modern computer is a very general and powerful device but, in itself, offers little of value as a psychological model. Computer models should address themselves to the known body of facts of human language processing. The frequent goal in artificial intelligence is to develop programs that can succeed in some task without consideration of their psychological implications. The purpose of this approach is to promote a more psychological perspective in artificial intelligence research.

Division of the Approach

Two programs in artificial intelligence are described. They focus on models of the adult competences underlying language understanding and on models of the acquisition of these competences. There are other areas, such as problem-solving and pattern perception, which may also be useful. Recommendations about such artificial intelligence applications may be found in the reports of Panels 1 and 4.

Program 2.6.1: Models of Language Understanding.

Program Statement

The purpose of this program is to develop computer models of the process of language understanding.

Program Potential

Computer modeling of language understanding serves to develop, test, and integrate ideas about the mechanisms underlying language comprehension. It is realistic to expect that this research will shed considerable light on the role of syntactic, semantic, and conceptual factors in language understanding. Current models are addressing the role of memory (world knowledge) and inference making in language understanding.

Program Research Considerations

The currently most popular task domain for applications of computers to language is in constructing systems that interact with users in their own language. Question-answering systems are the most common; users can interrogate the program about knowledge in its data base and add new knowledge. Such systems depend critically for their success on making the right decisions on three aspects of their design--the parser, the representation of information, and the inference system. The task of the parser is to analyze natural language input and translate it into a form compatible with the internal representation. If the input is something to be remembered by the system, it will be translated into an internal representation and stored in that form. If the input is a question, it will be used to guide the interrogation of the data base for the answer. The inference system is critical in the answering of questions, because many answers will not be directly stored. They will have to be inferred from what is in memory.

Both parsing and inference-making run into a potential time problem: unacceptable amounts of time may be required to perform these tasks on the computer. These difficulties may not emerge in restricted task domains, but could occur in existing programs if they were generalized to understand language in the general domain of human discourse.

These time problems are relevant to the psychological viability of these approaches. For instance, it can be questioned how the time to parse (understand) a sentence will increase with the length of the sentence. For humans, the time increases more or less linearly. In some parsing algorithms, time increases with the square or cube of the sentence length or even exponentially. Such algorithms are clearly unrealistic psychologically. Individuals proposing computer models should address themselves to such questions as processing time.

Another limitation with past research on language understanding is that it has focused on the single sentence. We should encourage research on larger units of discourse. We should give particular emphasis to the tying together of inferences made from individual sentences so that sentences in a text relate to each other, and to the use of world knowledge to disambiguate text and place things in their proper perspective.

Division of the Program

Some recent approaches have recognized the need to use "world knowledge" or contextual information to remove ambiguities in the interpretation of text. Other models can "learn" various rules for understanding. We should encourage the attention to psychological relevance in the design of these models.

Among other findings, artificial intelligence work on language understanding has indicated that the exclusive emphasis on syntax during the past decade was misplaced. Semantic and contextual information is also required to analyze properly incoming discourse.

How to draw inferences from the incoming information is of critical importance, but computer simulation work has shown the problem to be one that involves more than formal logic. People err in logic in ways that suggest there are rules (in addition to those of formal logic) in conversation and the understanding of events needed to draw inferences from discourse.

A model which comprehends discourse should be one that can receive new input, answer questions on it, summarize it, paraphrase it and, at the same time, be a theory of how people perform the same tasks. Such a model would constitute a theory of the reading process.

The following are the sort of projects that should be performed.

Project 2.6.1.1: Psychological Relevance of Parsing Algorithms.

Develop a research program to test various psychological assumptions embodied in recent parsing systems.

Project 2.6.1.2: Models of Long Term Memory.

Develop process models which will retrieve the information in memory relevant to a particular piece of discourse (see Panel 1). These models can add appreciably to our understanding of how individuals use stored knowledge to interpret new inputs. They are also critical to the development of experiments that test the psychological reality of computer representations of meaning.

Project 2.6.1.3: Models that Learn.

Develop process models that add new information to what already is known and stored in long term memory.

Project 2.6.1.4: World Knowledge.

Develop process models that apply world knowledge to the understanding of text.

Project 2.6.1.5: Inference Making.

Develop a process model for drawing inferences from discourse that are relevant to questions, instructions, or goals of a task.

Project 2.6.1.6: Derivation of Procedural Knowledge.

Develop models which can appropriately respond to instructions, questions, and other aspects of discourse requiring procedural semantics.

Project 2.6.1.7: Intentions in Discourse.

Develop a process model for ascertaining the intentions of speakers and writers of a discourse, sentences, or stories.

Program 2.6.2: Computer Models of Language Acquisition.

Program Statement

The purpose of this program is to develop a computer model of learning mechanisms that underly the acquisition of language skills.

Program Potential

Computer work on the acquisition of language is a natural complement to the work on language-understanding systems. Computer language systems are often criticized as being too "rigid." Our linguistic competence is not a fixed capability: Over the years we learn new grammatical styles, new words, and new ways of thinking. To a lesser extent this is also true over shorter periods: We adjust our understanding to context. A learning program is an attempt to incorporate such linguistic plasticity into a computer system.

Another problem with preprogramed language understanding is that it is, as a practical matter, impossible to put into the program all the knowledge requisite for understanding language in the general context. The amount of knowledge required is so large that one cannot realistically hope to be able to compile it all, organize it, and incorporate it into a program so that all the specific facts interact in the intended ways. A language acquisition system is a mechanized bookkeeping system which, in principle, would self-organize all the requisite information given appropriate linguistic experience.

Work on language acquisition systems has an additional contribution to make to the understanding of the reading process over and above its contribution to our understanding of language acquisition. One can expect to see positive transfer from the understanding of the acquisition of one skill, namely, comprehension of spoken speech, to the understanding of another skill, such as reading. The processes of understanding and producing spoken language are not very different, in the abstract, from the processes of reading and writing. In both cases, processes have to be developed that go back and forth between linguistic stimuli and some mental representation of their meanings. Moreover, in neither case is the relationship between the structure of the linguistic message and its meaning a direct or simple one. Because of the apparent arbitrariness of the relationship, it can be shown that there are logical problems in the induction of a set of mechanisms that are capable of translating between meanings and words (see Anderson, 1975 and Gold, 1967). To surmount these problems, some constraints on that relationship are required.

One should expect to see a reasonably direct translation from a language-learning mechanism to mechanisms that learn to read. To illustrate, consider the example of learning to read and use a recipe. Like spoken discourse or other forms of written discourse, a recipe has its own structure or grammar. However, the structure of a recipe is not like the structure of other discourse. So, the learner has to acquire a new set of mechanisms to deal with it. The mechanisms must go from a structured set of symbols (the recipe) to their meaning--which in this case is a set of procedures for cooking the desired object. Suppose we had a learning system which could go from a spoken sentence structure (a set of acoustic symbols) to its meaning. Then there is no apparent reason why these learning mechanisms could not apply in total to the learning of how to read a recipe. There are no complexities in the relationship between a recipe and its meaning which are not found in the relation between a spoken sentence and its meaning. In fact, the recipe is a much simpler problem.

Program Research Considerations

In psychology, a great deal of research on language acquisition has been conducted in the past 15 years. The research of the 1960s was principally concerned with understanding how syntactic information is acquired; little attention was paid either to the acquisition of semantic competence or to the role that children's general conceptual competence might play in language acquisition. This probably reflects the heavy emphasis laid on the study of syntax by Chomskian linguistics of the period. There is now a greater emphasis on semantics in linguistics. Correlated with this shift in emphasis, there has been a complete change in the field of child language research. The emphasis is now on acquisition of the semantic aspects of child language and the role of general cognitive factors in language acquisition. (See also Approaches 2.4 and 2.5.)

It is also the case that, until recently, computer models of language acquisition were concerned with the development of a syntactic characterization of the language. There were no attempts to learn how to convert mental representations of meaning into a linguistic message or to interpret the meaning of messages. However, this too is changing. At least three researchers--Anderson, Klein, and Siklossy--have recently worked on programs to deduce the meaning-sentence relationship.

Psychological research has developed an extremely rich body of data on semantic and general conceptual factors in language acquisition. However, for all this empirical data, there is a woeful lack of rigorous theoretical analysis. Current theoretical analyses consist either of correlations between linguistic concepts and behavioral data, or similar correlations between theories like Piaget's and the data. There has been no attempt to specify process models for language acquisition and to rigorously establish their ability to generate human linguistic competence.

The time is ripe to bring together the computer models of language acquisition and the actual data on language acquisition. Computer modeling and empirical research have a tendency to progress in ignorance of each other. In computer work, there is little attempt to account for the data. In fact, many of the language-learning programs have concerned themselves with a much broader class of languages than can be considered as possible natural languages. As in the computer work on language understanding, we would urge relating the computer model to the basic facts known about the psychological phenomena.

It can be shown that no workable program can learn all conceivable languages, so researchers with computer-learning models should be encouraged to specify what languages their programs will learn. Alternately and equivalently, they should specify what assumptions their program is making about natural language. Specifying this information would be a useful contribution to the research on language comprehension.

Programs that learn small fragments of natural language now exist. For instance, the Winograd program learns to talk about a simple two-dimensional world of geometric shapes, their properties, and spatial interrelations. A typical sentence the program might have to deal with follows:

The small square is right of a triangle which is above a blue square.

The program learns by being presented with pictures (actually network descriptions of these) and sentences that describe the picture. After limited exposure to such pairings of sentence with picture, the program is able to understand novel sentences, generate sentences to describe pictures, and paraphrase sentences. After being trained in two languages, such as French and English, it can translate between them (cf. Approach 2.5).

Division of the Program

Preliminary work such as the above shows that computer modeling of language acquisition is a feasible goal. The next logical step is to attempt to extend these methods to larger and more representative portions of natural language. The following are examples of projects that we should support:

Project 2.6.2.1: Information-Processing Limitations.

It would be useful to simulate the basic information processing demands that face a human language learner. Programs should deal with the impact of memory limitations on information processing. The learning mechanism should apply in a left-to-right manner to incoming sentences if psychological data indicate that children operate in this way on the sentences from which they must learn.

Project 2.6.2.2: Lexicalization.

Lexicalization is the name of the process by which children learn the meaning of words. The meanings of some words, like dog, seem to be acquired through ostensive training on the possible referents of such words. However, the meanings of other words are learned by their context in spoken speech. For example, children learn the case frames of verbs and the selectional restrictions on what may fill these frames. Also, we know that children will attend to some words and ignore others. It would be worthwhile to model the processes that select a word for attention and learn its meaning (see Panel 1, Approach 1.1).

Project 2.6.2.3: Procedural Semantics.

Procedural semantics is a method for guessing the meaning of a word by knowledge of (a) what has been already read and (b) what one knows about the word. For example, a given word may have two meanings. One method for choosing the appropriate meaning may be to notice the fact that the word is used as a noun rather than a verb (e.g., bat) in a given context. The procedures involve knowing rules for combining words into sentences as well as dictionary meanings. Winograd has shown that many of the purposes of discourse are not simply to convey information. Questions require the language understander to evoke procedures to retrieve answers. Instructions require other procedures to be evoked to comply with the instructions. Language learning programs should deal with the acquisition of procedural semantics.

Project 2.6.2.4: Grammar Optimization.

One of the major problems with language understanding programs is the time problem, that is, the problem of getting the program to deal with wide ranges of discourse without taking inordinate amounts of processing time. Presumably, people learn heuristics that make language processing more efficient. It would be significant to incorporate into a language learning program mechanisms for inducing such heuristics. One might incorporate optimization of the grammar with respect to amount of backtracking required in parsing. One might also try to induce techniques for predictive parsing such as those built into Schank's (1972) program.

PRIORITIES AND RECOMMENDATIONS

General Discussion

Because the panel generated the above six approaches we felt it would be self-serving to make priority judgments. Our reluctance to evaluate the proposed problem areas was also influenced by some implicit prioritizing; namely, we proposed certain research areas and did not, for various reasons, propose others. Further, in our rationales, we indicated approaches that have been tried and abandoned, and ongoing approaches which do not seem to be progressing. We are dealing with a basic research field and it is difficult to predict success, breakthroughs, or accelerated development in an area. Some of our proposals entail maintaining and furthering ongoing projects (Approaches 2.1 through 2.3; Program 2.6.1), others extend a sound technology and formal approach (Program 2.6.2), and yet others advocate an initial exploration into large, important problems which do not yet lend themselves to precise analysis and experimentation (Approaches 2.4, 2.5; Program 2.6.2).

Our view of the task is that we are establishing approaches which would serve as "bait" for new, imaginative research proposals by persons with substantial scientific or scholarly ability. We would prefer judgments to be made in terms of:

1. Quality of proposed research by the principal investigator,

2. Scientific merit of the research (is it feasible, sound, logically consistent, etc.),

3. Intellectual quality of the investigator (including prior history of productivity and creativity, formal skills, commitment, promise, etc.).

This should be done by the NIE staff in consultation with a peer review committee.

Our approaches are broadly oriented. They operate parallel to each other, i.e., no program or project depends sequentially on others. The exception is Program 2.5.1, the identification of the bilingual population and samples. It is important that this program be completed before other programs within Approach 2.5 are started. Here, explicit and sound criteria for sample selection require careful development and thoughtful application. This program clearly has a higher priority than the others listed in that approach. There is little point in doing studies on "bilinguals" when it is not clear what kind of bilingual persons are being selected. It is also unwise to allow age, education, and other confounding factors to appear. We are trying to establish a legitimate basic research program on a specific kind of person with special kinds of social language experience. The whole enterprise rests on the initial selection work.

Approach 2.4 is very open ended. It stresses an orientation to and consideration of a long-neglected but obvious factor in the study of language comprehension. We cannot see the value of applying findings from basic research on language comprehension to the teaching of reading or the writing of texts if the research has not taken transfer phenomena into account, or if the findings do not generalize when context or social language use is involved. We therefore assign this approach a major priority.

Approaches 2.1 through 2.3 build upon the combined efforts of linguists and psychologists who do structural analyses of connected discourse. These approaches, we feel, are moving more established research strategies in the right direction--toward context effects within the text and away from the study of linguistic materials in isolation, toward accounting for pragmatics, assumptions of the speaker about the listener, and vice versa, and toward the social uses of language. In these fields, we believe that prime consideration should be given to the approach and quality of the investigation.

Approach 2.6 takes advantage of the fast-developing, powerful, formal methods in artificial intelligence research and computer studies of natural language understanding. We recognize that advances will occur here and have immediate impact. The possible importance of this area for computer-assisted instructional technology has not been explored by this panel but it should be pursued.

If I (Trabasso) were in control of limited funds, I would do the following: allocate some resources to all six approaches (2.1 through 2.3 are of one piece, so essentially we have four approaches); support those investigators in each approach who come up with proposals that meet high standards of scientific excellence and at the same time represent innovative, creative, and possibly seminal research.

A lower priority would be given to those proposals that merely extend, in small ways, what we already know.

I would regard support to a few promising proposals in each approach as <u>seed</u> money for developing the approach and its usefulness.

Consideration should be given to the funding patterns of other agencies. In artificial intelligence, small grants ($20-50 thousand) are not getting support. I would recommend support of this type to individual investigators who work, by and large, with computers and do not need large hardware and/or personnel support. In short, select a limited number of good, high-quality proposals in each area. None should be very expensive and all should yield information about the viability of the approach.

Listed Priorities

We feel we cannot reasonably be asked to do this, and defer to outside reviewers.

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